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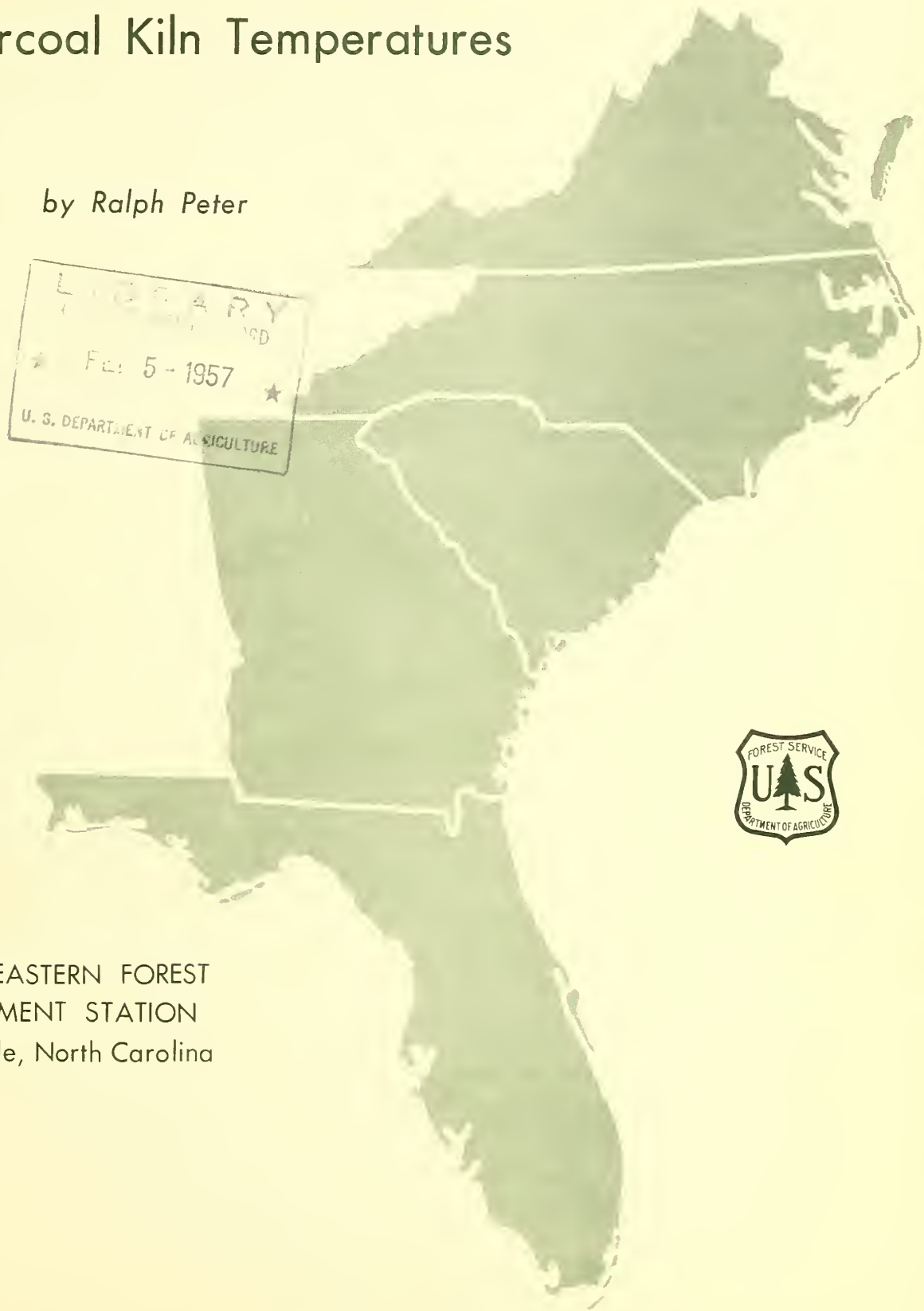

SOUTHEASTERN FOREST
EXPERIMENT STATION
Asheville, North Carolina

U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE

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AN INEXPENSIVE METHOD FOR MEASURING CHARCOAL KILN TEMPERATURES

by

Ralph Peter
Athens-Macon Research Center

During the production of charcoal in a cinder block kiln, it is important to control kiln temperatures, not only for the consistent production of quality charcoal, but also for the prevention of kiln deterioration due to excessive kiln temperatures. The present coaling procedures are based primarily on the color and volume of chimney smoke and on past operating experience gained by trial and error. Except possibly at the very extreme coaling conditions, color and smoke volume are not indicative of internal kiln temperatures. Temperatures have generally not been measured in production kilns because of the high cost of the equipment required and because of the relative inconvenience of instrument adjustments, use and care.

Tests have been made in the experimental 7-cord charcoal kiln located at Athens, Georgia, using an inexpensive standard brand D.C. microameter to measure kiln temperatures. After the instrument was calibrated to suit charcoaling conditions, it was tested during kiln operations. Good temperature comparisons were obtained between this inexpensive instrument and an accurate temperature compensating potentiometer, thus indicating that simple-to-operate, inexpensive equipment can be used.

Meter Calibration

The microameter when purchased is calibrated for microamps only. The new temperature scale drawn for the instrument is illustrated in figure 1. Copies included at the end of this report may be cut out and rubber-cemented directly over the scale furnished with the instrument to provide a reasonably accurate thermocouple pyrometer.

The temperature reading obtained with this instrument is the temperature difference between the actual kiln temperature and the temperature of the reference junction (fig. 2). The calibrations were made using 75° F. as an average reference junction temperature, or, in other words, average air temperature. For accurate kiln temperature readings, when the reference junction temperature is above 75° F. (use thermometer), add the difference between the reference junction temperature and 75° F. to the kiln temperature reading. If the reference junction temperature is below 75° F., subtract the difference. However, for charcoal kiln operations under average weather conditions this temperature correction may be omitted if desired. For extreme atmospheric temperatures, particularly winter conditions, the temperature corrections should be made.

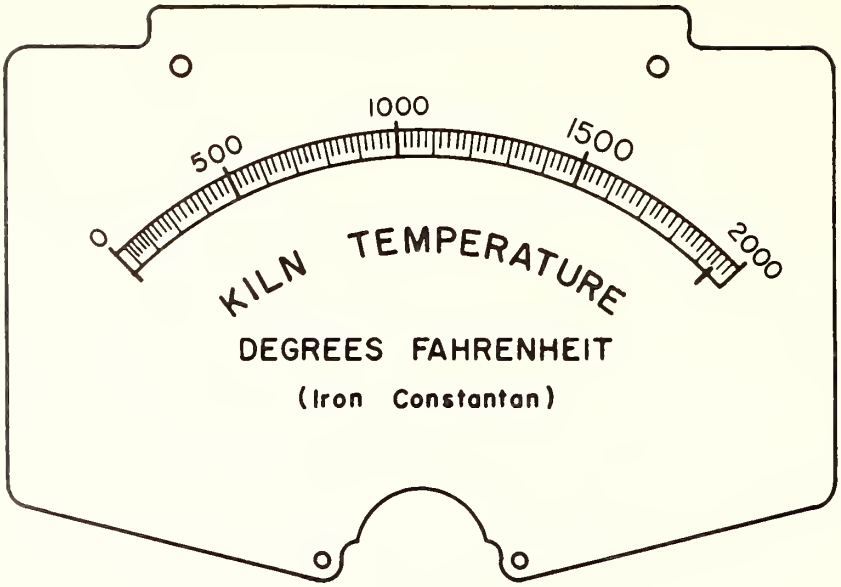


Figure 1.--New temperature scale.

Meter Requirements

The meter recommended should have a D. C. microameter range of 0 to 25 microamperes, and resistance of 2200 ohms.

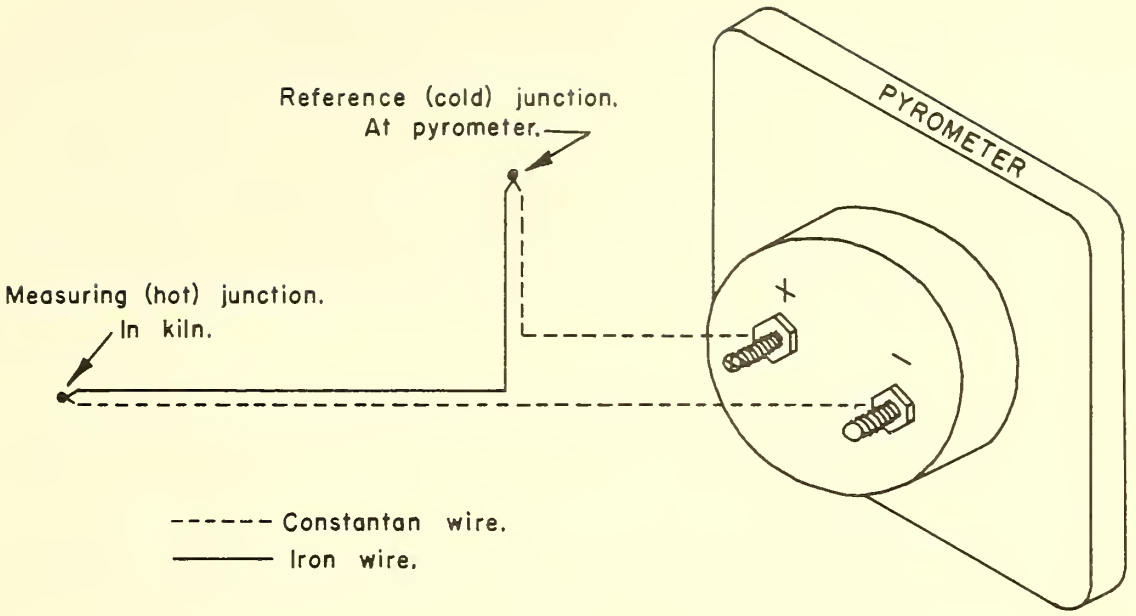
The scale furnished with the meter should be of the same size and shape as the scale shown in figure 1. The new scale cannot be substituted if the meter characteristics are different from the stated requirements.

Changing Scale

If the recommended meter is used, changing the scale is a simple matter. First remove the four recessed screws which hold the front cover of the instrument in place. Second, remove the four screws which fasten the scale plate to the meter case. Carefully slide the scale plate out from under the pointer without touching the pointer. Turn it over and rubber-cement the new scale (figure 1) to the back side. Replace the scale plate with the new scale showing, and carefully replace all screws in the inverse order to which they were removed.

Wire Requirements

The wiring system for measuring charcoal kiln temperatures is divided into two classifications. The wire located inside the kiln is called thermocouple wire, and the portion of the system on the outside of the kiln leading



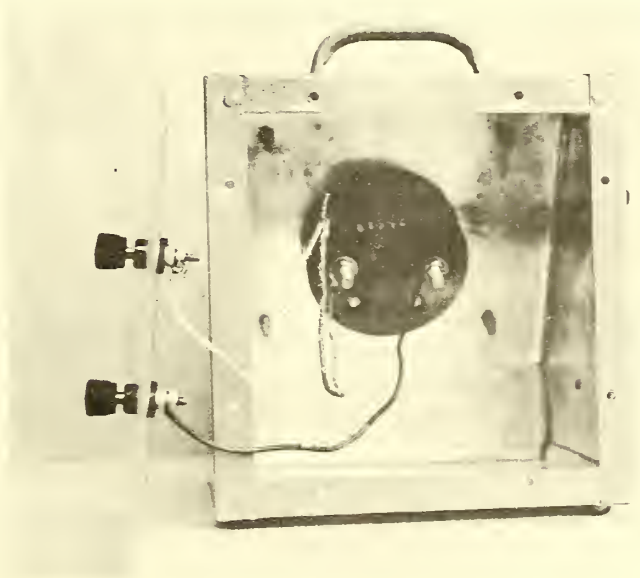


Figure 2.--Reference junction wiring

to the meter is called extension wire. Both the thermocouple and extension wire contain two strands of dissimilar metals, one of which is iron and the other constantan and is referred to as iron-constantan wire.

Insulation.--Many kinds of insulating materials are available. Each strand of the iron-constantan wire is insulated. The two insulated strands are then usually overwrapped with additional insulation to form a parallel paired wire. The thermocouple wire insulation must be able to withstand at least 1100-1200° F. and must be protected against abrasion. The insulation for the extension wire must be weatherproof if the wire is exposed to moisture during use.

Gage.--The heavier gage thermocouple wire will last longer than the lighter. The gage used for extension wire is based primarily on cost. The lighter gage costs less provided the type of wire and insulation are the same.

Condition of use.--Thermocouple wire may be used also as an extension wire provided that none of the wire on the exterior of the kiln is exposed to moisture. However, wire classified by manufacturers as extension wire should not be used for thermocouple application.

Recommended thermocouple wire.--The following information should be furnished the manufacturer: iron-constantan parallel paired thermocouple wire, 16 or 18 gage, solid, asbestos insulated, stainless steel mesh overbraid, amount of wire needed. The price of this wire is 28 to 30 cents per foot.

Recommended wire for use as extension.--The following thermocouple wire is recommended for use as extension wire because of the low cost: iron-constantan parallel paired thermocouple (or extension if available) wire, 24 gage, polyvinyl insulation. The price of this wire is approximately $3.00 per 100 feet.

Any iron-constantan wire constructed of any heavier gage (22-16) and of any weatherproof insulation may be used. The cost, however, may be as high as $15.00 to $17.00 per 100 feet.

Wiring of Meter, Maintenance and Use

The reference junction, which measures the air temperature in the vicinity of the meter, is made by taking a short piece of the constantan extension strand and attaching it to the positive or plus terminal of the meter. A short piece of iron strand is then twisted and soldered to this constantan strand as shown in figure 2. A slightly longer piece of constantan strand is attached to the negative or minus terminal of the meter. If there is any doubt as to the identify of the strands, a magnet can be used to identify the iron strand.

Binding posts, clips, or jacks should be attached to the two ends of the above mentioned strands so that the meter can be easily moved from one thermocouple to the next; or for convenience, the extension wires leading to the thermocouples can be passed through a multiple switch. By using the switch arrangement, it will not be necessary to move the meter.

The meter should be handled as a delicate instrument and should be protected from the weather. Preferably, it should be mounted on a panel or in an instrument box similar to the one shown in figure 2. When the meter is disconnected from the thermocouples, the needle should be on the zero line of the meter scale. Needle adjustment can be made by turning the screw head on the face of the meter.

It should be remembered that the meter is calibrated for a reference junction temperature of 75° F., and deviations from this temperature will result in some error. During the hot summer months, the meter should be placed away from the kiln wall so that the heat from the kiln will not increase the temperature of the reference junction more than the air temperature. During winter operation, when extreme cold temperatures can be expected, it may be desirable to increase the reference junction temperature by placing the meter near the kiln. If this is inconvenient to do, the temperature correction should be made.

Thermocouples

Many types of commercial thermocouples are available and may be purchased ready for use. However, the thermocouples can be made by the charcoal kiln operator at small cost. Strip approximately 1 inch of insulation from the end of the thermocouple wire of appropriate length and twist the two strands together. This forms a thermocouple. For best results, the tip of the twisted strands should be welded together as shown in figure 3.

Thermocouple Placement

The kiln can be wired for any number of thermocouples. For a 7-cord kiln or larger, at least five thermocouple locations are recommended. All five thermocouples should be located along the lengthwise centerline and inserted through the roof as shown in figure 4. The front thermocouple should be located 1 foot behind the kindling area, the second at kiln center and the third 2 feet from the rear wall. All three thermocouples project only 6 inches down from the ceiling. Thermocouple 4 is inserted through the same ceiling hole as number 2 but projects halfway down into the kiln. Thermocouple 5 is located by number 3 but projects down into the kiln to within $2\frac{1}{2}$ feet of the floor. Since the thermocouple wire is flexible, it will conform to the wood which is placed around it. During unloading, the two longer thermocouples can be swung out of the way.

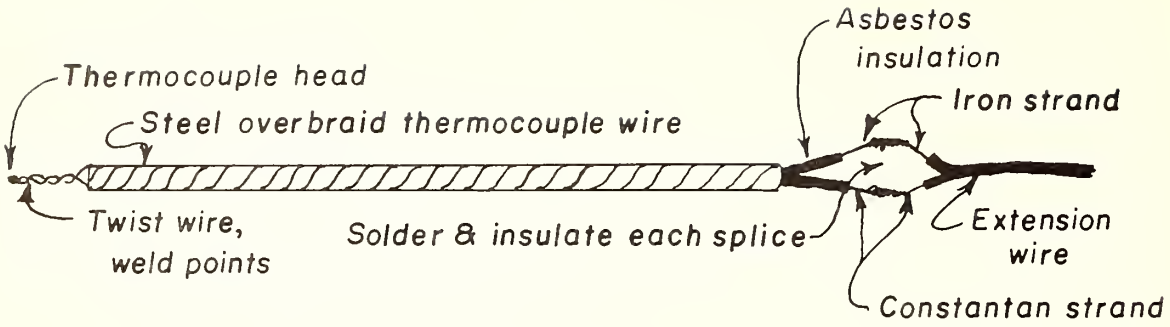


Figure 3.--Thermocouple construction.

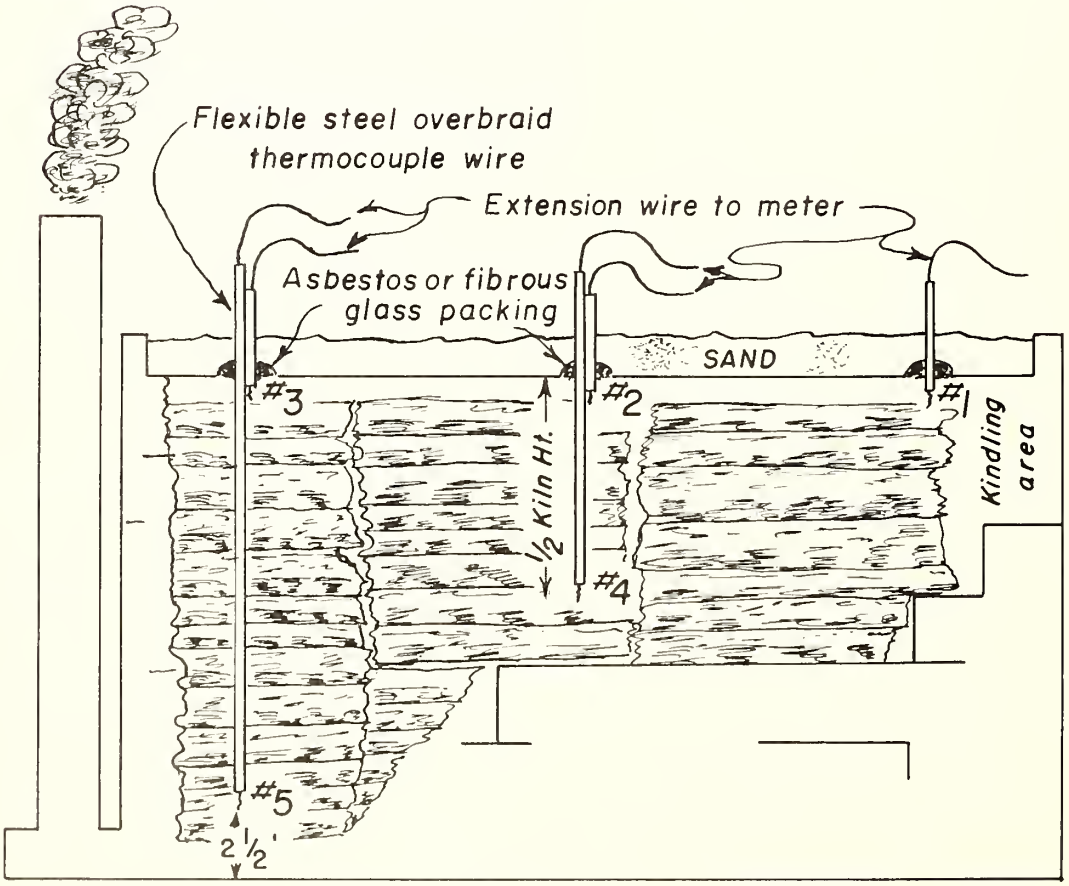


Figure 4.--Thermocouple location.

Optional thermocouples can be suspended from the ceiling near the kiln wall or can be mortared into the wall at various heights during kiln construction in such a manner that the head of the thermocouple projects into the kiln only an inch. These additional thermocouples will enable the operator to keep a closer check on coaling uniformity and on kiln wall temperatures to prevent deterioration due to excessive temperatures of over 950° F.

The thermocouples projecting into the kiln through the ceiling should be wired to the roof support to prevent them from slipping into the kiln. The exterior sections of the thermocouples are connected to the extension wires. Care must be taken that the iron strands of the thermocouple wires are soldered to the iron strands of the extension wires and the constantan strands to the constantan strands. It is also desirable to insulate these connections to prevent accidental shorting of the circuit.

Temperature Pattern and Temperature Control

The temperatures recorded on thermocouple number 1 during the firing operation depend on several factors: amount and condition of kindling, amount of fuel oil added, amount of available oxygen and direction of draft. If conditions are good and the kiln has rear ceiling ports to vent the smoke during the firing phase, temperatures of 1200-1400° F. may be expected. This high temperature should not last longer than 10 to 15 minutes and should be permitted only in kilns with metal ceilings.

Temperature pattern.--After the initial flare-up, the average temperature recorded on thermocouples 1 through 3 is expected to decrease greatly. If temperatures of 500-600° F. have been reached, maintained, and gradually increased over a period of a few hours across the top of the kiln charge, the operator can feel assured that precoaling conditions have been reached. This temperature should be permitted to increase to 900° F. for good coaling condition and should be maintained during most of the burn. During this period, temperatures recorded on thermocouples 4 and 5 are gradually increasing. It is to be expected that the wood in the vicinity of thermocouple 5 will be the last to reach coaling temperature.

As the wood coals, it gradually settles, moving further away from the top three thermocouples. During the latter part of the burn, the average temperature for thermocouples 1 through 3 may decrease slightly. However, the temperatures recorded at thermocouples 4 and 5 should still be increasing.

The end of the coaling period is indicated by the thinning out of the chimney smoke. At this time, it is desirable that thermocouples 4 and 5 record a temperature of at least 825° F., and this temperature should have been maintained for several hours prior to kiln closure.

Temperature control.--The temperature control method is a simple procedure of increasing the air intake if the temperature is too low, or decreasing the air intake if too high.

To maintain accurate temperature measurement conditions, the thermocouples should be replaced occasionally because of a gradual decrease in accuracy through use. A break or a short circuit in the wire may be indicated by no meter response or by the meter needle swinging past the high scale mark. If the kiln is to be inoperative for an extended period of time, it is advisable to coat all the exposed iron strands of the wiring system with a light oil to prevent corrosion.

Partial List of Suppliers*

Microameter - Price approximately $20.00

Allied Radio 100 N. Western Ave. Chicago 80, Illinois	Catalog No. 160 Stock No. 67F444 D. C. Microameter, Range 0-25 2200 ohms internal resistance
Burstein-Applebee Company 1012-14 McGee Street Kansas City, Missouri	Catalog No. 571 Stock No. 29A1338 D. C. Microameter, Range 0-25 2200 ohms internal resistance
Newark Electric Company 223 W. Madison Street Chicago 6, Illinois	D. C. Microameter, Model 29, No. 55F175, Range 0-25, 2200 ohms internal resistance

Thermocouple, thermocouple wire and extension wire

Most of the companies have state or regional representatives which cannot be listed here. The home office addresses are:

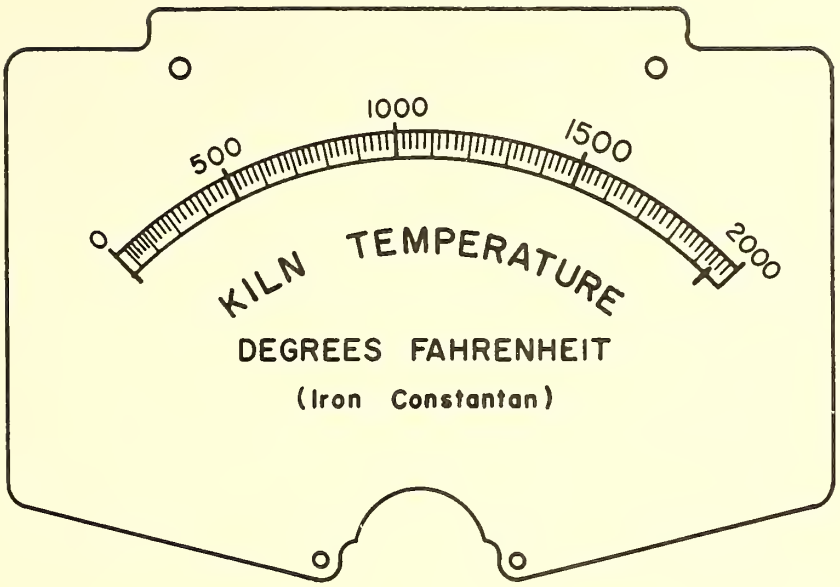
The Bristol Company
Waterbury 91, Connecticut

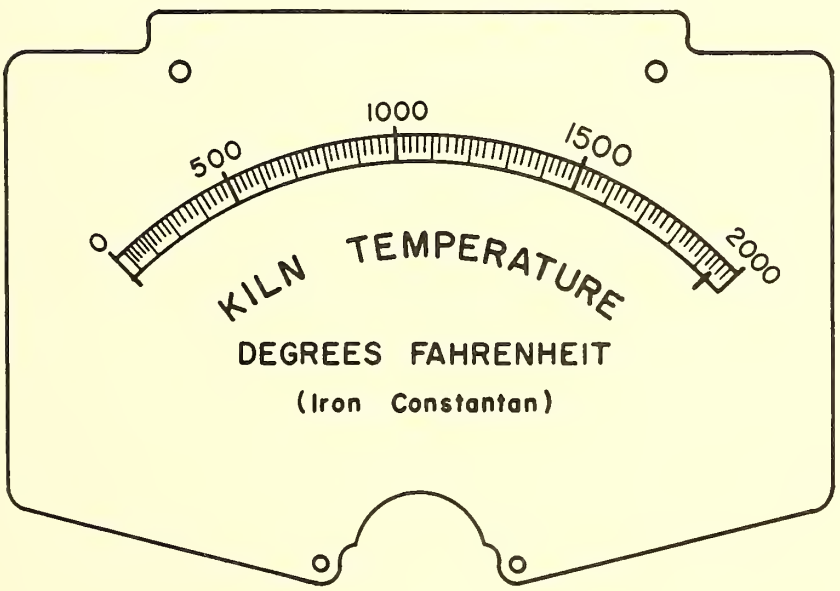
The Lewis Engineering Company
Naugatuck, Connecticut

Thermo Electric Company, Inc.
Saddle River Township
Rochelle Park Post Office, N. J.

Minneapolis-Honeywell Regulator Company
Wayne and Windrim Avenue
Philadelphia 44, Pa.

* The inclusion or exclusion of names in this list does not imply endorsement or lack of endorsement of any company or products by the Forest Service.





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